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14. ABSTRACT The primary objective of this project was to develop an algorithm for time-series simulation of target-like bottom clutter, and add it to the Sonar Simulation Toolset (SST). Toward that end, we added location-dependent bottom types to SST, added bottom-slope corrections to the scattering strengths and reflection coefficients, and made several of the algorithms sensitive to the locations of surface and bottom reflections. We also made several changes to improve SST's efficiency, usability, completeness, and correctness. The primary deliverables were two releases of SST; we also pushed through publication a major report and a JUA(USN) invited paper reviewing SST's science and math.					
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Contract Information

Contract Number	N00014-01-G-0460, Delivery Order 0029
Performance Period	3/3/2004 - 3/2/2005
Awarded	\$100,000
Title of Research	Sonar Simulation Toolset: Clutter Modeling and Support
Principal Investigator	Dr. Robert P. Goddard
Organization	Applied Physics Laboratory, University of Washington

Technical Section

Technical Objectives

From the proposal:

APL-UW will work closely with experts in the field, especially including Tony Lyons of ARL-PSU, to specify a statistical model for target-like bottom clutter. We will implement that model using some combination of non-Gaussian reverberation, spatial variability of bottom and volume scattering strength, and random placement of "false target" features.

Technical Approach

From the proposal:

Task 1, Development: Identify an appropriate statistical model for target-like bottom clutter, working with experts in the field. Design an algorithm for creating signal-level realizations of that model. Implement that algorithm as an additional capability in the Sonar Simulation Toolset (SST), integrated with SST's existing functionality. Test the results against the statistical model. Document the new capability by adding to SST's existing documentation. Make the new version of SST available to users throughout the Navy R&D community.

Task 2, Validation: Identify one or more appropriate data sets. Begin the process of validating SST's new clutter generation algorithm by processing SST's simulated data and the measured data through similar, reasonably realistic detection algorithms and comparing the false target rates. We expect that the resources requested will be insufficient to do a more complete validation, including false alarm rates after tracking and classification algorithms and multiple data sets.

Task 3, Support: Support SST users in the Navy undersea weapon community by providing advice on using SST effectively and by improving SST's documentation, usability, performance, and realism in response to user requests. Approximately 20% of our effort will be allocated to this task.

Progress

The "year-end" progress report for this project was delivered in early September 2004, even though that point was only halfway through the term of the contract. This final report briefly summarizes that one, and updates it to the contract end, 2 March 2005.

The refereed paper describing SST has finally appeared in JUA(USN). The full citation is:

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- Robert P. Goddard, "The Sonar Simulation Toolset," U. S. Navy Journal of Underwater Acoustics **54** #1 (January 2004), pp. 193-232.

The journal is SECRET, but the paper is unclassified, restricted to DoD or DoD Contractors Only. Despite the cover date, it actually appeared in June 2005.

Most of the same information, plus more detail and minus a sensitive section on applications of SST, is in a new Technical Report:

- Robert P. Goddard, "The Sonar Simulation Toolset, Release 4.1: Science, Mathematics, and Algorithms," Technical Report APL-UW TR 0404, Applied Physics Laboratory, University of Washington, Seattle (March 2005).

The cost of editing both the paper and the report was shared among several SST-related contracts. This contract had a minor share, since most of the writing was done in 2003 and early 2004.

Two releases of the SST software were distributed during this contract: SST 2004.6 (June 2004) and SST 2004.11 (November 2004). New features include the following:

- Bottom and surface characteristics (including scattering strength and forward reflection coefficient) can depend on location. This works with all of SST's propagation models, not just CASS/GRAB. This is a key step in clutter modeling (Task 1).
- The angles used by the bottom models to compute scattering strengths include a correction for local bottom slope. This, too, was identified by users as important for modeling clutter (Task 1).
- Information about the locations and angles of each eigenray's reflections is produced by a new feature of CASS, the SEPES eigenray model. SST uses those data in the time spread algorithm, eliminating a fairly gross approximation.
- The SumSignal operation now works for signals having different start and end times. This makes mixed passive+active and multiple-target scenarios much easier to specify and faster to compute.
- A new example run shows how to generate modulated broadband signals for DEMON processing. This is an important part of a passive signature.
- Another new example run shows how to generate unstable tone families, another important part of a passive signature. This one is implemented partly in SST and partly in Matlab.
- Both releases also include several important error corrections, and improvements in the Matlab scripts supplied with SST to support analysis and visualization of SST results (Task 3).

After the November release, we worked on a technique for randomly generating a position-dependent bottom with a specified spatial correlation function, and a set of MATLAB tools to make it easier to create a graphical user interface (GUI) in Matlab to control SST simulations.

We have continued to provide telephone and email support for SST users in the torpedo community. This involves answering questions, reviewing scripts, tracking down problems and suggesting solutions. This has been an especially busy period for this activity. This is good news, as it indicates that SST is being actively used by many people, including new users.

Education Mission

For the last half of 2004, our team included a student, Brandon Smith, who started graduate studies in the UW Electrical Engineering department in autumn 2004. He took the lead on the DEMON and unstable tone features, and worked on closer integration between SST and MATLAB, including the GUI front end. As a result, he carried a deeper understanding of signal processing and sonar into his thesis work.